Sensitivity to low-frequency temporal fine structure is correlated with aided spatial release from masking

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Introduction

- Binaural hearing is necessary for localizing sounds accurately, and for making sense of complex listening environments with many sound sources.
- It is important to understand which binaural cues are beneficial for spatial hearing in hearing aid users to inform hearing aid design.
- Temporal fine structure, TFS, is thought to be important for voice recognition, segregation of competing talkers, and listening in the dips of a fluctuating background (Hopkins et al., 2008; Zeng et al., 2005; Lorenzi et al., 2006). Hearing-impaired listeners have a reduced ability to use TFS information (Moore et al., 2006; Hopkins and Moore, 2007; Hopkins and Moore, 2010).
- Hopkins and Moore (2010) developed a fast method for measuring sensitivity to binaural TFS (the ability to detect interaural phase differences, IPD, of pure tones) at low frequencies: the TFS-LF test.
- To investigate possible correlations between binaural TFS abilities and spatial hearing, the opportunity was taken to make use of some earlier data on aided spatial release from masking (Neher et al., 2009). In that study, large inter-subject variation in spatial release from masking was observed, and it was hypothesized that this variation could be related to binaural TFS abilities. The TFS-LF test was used as the same tests as tested by Neher et al.

Methods

- The TFS-LF test (Hopkins and Moore, 2010)
  - Same signal to both ears
  - Usually lateralled centrally
  - Inter-aural phase shift, $\Phi$, in right-ear TFS only
  - Using a TFS-LF test

- Spatial Release from Masking (Neher et al., 2009)
  - Speech material based on Dantale 2 material, re-recorded with three female talkers (see Neher et al., 2009)
  - Three anechoic conditions:
    - Reference (Ref): No spatial benefit
    - Left-Right (L-R) Spatial benefit due to TDs and ILDs
    - Front-Back (F-B) Spatial benefit due to monaural spatial cues
  - Sensitivity to TFS-LF (mean = 58 years, aged 28-75 years)

- Hearing aid procedure
  - Bilateral hearing aid fitted to preserve spatial acoustic cues:
    - CIC devices with "optimal" microphone position (6 output bandwidth of ~7 kHz)
    - Long (500-msec) release times to better maintain ILDs
    - Extra gain between 2 and 6 kHz based on aided threshold measurements to ensure audibility of high-frequency speech sounds
    - Noise reduction disabled
    - Acclimatization period of 3-4 weeks
    - Cognitive tests:
      - Reading span test (Daneman & Carpenter, 1980)
      - Test of everyday attention (Roberson & Robertson, 1996)

- Co-variates with the TFS-LF test

- Correlations TFS-LF vs. Spatial tests
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- Results

- Conclusions

In experiments where audibility was ensured and in a spatially complex, multi-talker situation, we found:
- Large inter-subject variation in spatial release from masking
- Binaural TFS abilities were correlated with speech recognition with maskers in the Left-Right condition
- Binaural TFS abilities were correlated with age and some cognitive measures, but not with pure-tone hearing thresholds

References